ACCIDENTAL EXPLOSIONS *

III.

A FEW substances well known to chemists are so very unstable in character, or are so very difficult to prepare in a condition approaching purity, that they either begin to undergo change as soon as they have been produced, or very shortly afterwards, such change proceeding sometimes gradually and quietly until the substance has been transformed into non-explosive bodies, or occurring, in other instances, with a rapidity speedily resulting in the violent decomposition or explosion of the substance. Injuries more or less severe have been inflicted upon the discoverers or investigators of substances of this kind, or upon those who prepare them and exhibit their properties for instructional purposes, and such accidents occasionally occur even though all possible or reasonable precautions appear to have been taken to guard against them. It has occasionally also happened that serious accidents have resulted from attempts to apply to practical purposes the explosive power of such substances (as, for example, the chloride of nitrogen and iodide of nitrogen) by persons imperfectly acquainted with their properties or those of explosive substances generally. The great danger in which want of knowledge may involve experimenters in this direction is too obvious to need being dwelt upon.

The risk of accident resulting from the liability of explosive compounds to so-called spontaneous decomposition has been on several occasions exemplified in the past history of the two most important of these compounds, gun-cotton and nitro-glycerine. The stability of properly purified gun-cotton, as well as that of nitro-glycerine, have, however, now been for some time past fully established, and no difficulty exists in carrying on with safety their manufacture on such a scale as to satisfy the continually increasing demand for efficient preparations of these violent explosive agents. At the same time the experience of the last few years has afforded repeated illustrations of the terrible risks and responsibilities incurred by manufacturers of these substances by the slightest departure from conditions essential to perfection and safety of manufacture, or by a relaxation of the strictest supervision in the production, purification, and storage of the materials.

In these respects the utilisation of explosive compounds of this class involves special risks not attendant upon the manufacture of gunpowder and modifications of that substance; in others, however, it presents important elements of comparative safety. For example, the manufacture and purification of gun-cotton, and its conversion into the compressed or granulated substance, are absolutely safe operations, the material being wet throughout the entire course, and therefore quite uninflammable, until, when completed, it is dried by long exposure to air, or by artificial heat. On the other hand, gunpowder, and all preparations of similar nature, are explosive from the very commencement of their manufacture.

Accidents at gunpowder factories are very frequent, and though they may not often involve considerable loss of life or destruction of property, the fact that their occurrence must in most instances be caused by partial, occasional, or complete and persistent neglect of precautions absolutely essential to the safety of the people employed in the works, or to a reduction of the risks of accident to the minimum, points to the necessity for improved legislation connected with manufactories of gunpowder and other explosive preparations, whereby the proper attention to regulations and precautions for safety may be rendered compulsory, and seconded by an efficient system of inspection.

After stating a number of precautions that ought to be adopted in all gunpowder manufactories, Prof. Abel said that lastly, though properly first in importance, the manufacturers of gunpowder and other explosive agents should not only themselves possess some scientific as well as a practical knowledge of the nature and properties of the substances in the manufacture of which the lives of their workmen are at stake, but they also should ascertain and insist that at any rate the persons who act as managers and foremen in their factories should not be deficient in the elementary knowledge indispensable to a proper performance of their duties.

Major Majendie, the Government Inspector of Gunpowder Works, &c., has reported officially that he was "much struck, in the course of his inspections, with the extraordinary ignorance of even the most elementary dangers, and the precautions necessary for avoiding them, which prevails among persons in charge of important factories and magazines," and that there can be no doubt that to the ignorance and incompetence of such persons a large number of the accidents which occur are indirectly due. Surely it is in the interest of employers to adopt measures for securing that the management of their works is in the hands of competent men, experienced in the details of the manufacture, and possessing adequate general education and technical knowledge to fit them for posts of such responsibility. The obvious mode of securing this is to render it compulsory for such men to obtain certificates of competency before they can hold responsible appointments in manufactories of gunpowder and other explosive agents.

The manufacture of fireworks, ammunition, percussion caps, and other articles involving the application of explosive agents is, it need scarcely be stated, attended by liability to accidents similar to and sometimes even greater than that existing in manufactories of gunpowder and materials of similar nature, and necessitates the adoption of precautions of the same nature as apply to these works.

Such necessity has, however, been very much disregarded in the arrangement and management of factories of this kind, and many very sad casualties have resulted either from utterly inadequate arrangements for localising explosions and reducing them to small proportions, by regulating the quantities of material dealt with in one building, and sufficiently separating and subdividing the manufacturing operations, or from neglect of simple regulations for excluding sources of fire from the buildings.

There are several important instances of accidental explosions on record which have occurred in the manufacture of pyrotechnic compositions and other articles of explosive nature, in consequence of a liability to the establishment of chemical activity between the ingredients of such preparations by even very slight inciting causes. Thus, certain descriptions of coloured fires are readily susceptible of so-called spontaneous ignition or explosion, either simply from the unstable nature of one or other of their ingredients, or from so apparently trifling a cause as the absorption of a small amount of moisture, or the employment of a small quantity of an easily oxidisable oil or fat in connection with their application to pyrotechnic purposes. In one instance, some signal lights, composed of a mixture of ingredients which long experience had shown to be in every way as permanent as those of gunpowder, were found to be undergoing decomposition to an extent which, had it not been noticed in time, must have resulted in serious consequences. The cause of this change baffled inquiry for some time, but ultimately it was clearly established that a very minute quantity of free acid contained in the paper linings of the cases in which the composition was confined (and derived from the antichlore used in the manufacture of the paper) had set up an action between the saltpetre and the orpiment composing this material, which spread gradually but with increasing rapidity through the highly compressed mass, being of course accelerated by the heat developed.

After referring to the great dangers arising from the manufacture of fireworks in dwelling-houses of the lower classes in crowded districts, the lecturer said that the fearful recklessness with which gunpowder and other explosive agents are handled and used by uneducated persons, such as these small firework makers, of which there are large numbers in the mining and manufacturing districts, and by the most extensive consumers of powder, namely, the miners and quarrymen, can scarcely be realised by anyone who has not had opportunity to acquire by personal observation a knowledge of the state of things.

Prof. Abel then gave instances of the incredible carelessness frequently shown by miners in their preparations for blasting both with gunpowder, gun-cotton, dynamite, and other explosive substances.

It is, however, more particularly from the fact that there are no regulations forbidding or restricting the making up, in dwelling-houses, of blasting cartridges, mining fuses, and the so-called powder straws used in blasting, that the chief liability to accidental explosions in mining districts arises. Miners are constantly in the habit of keeping considerable quantities of powder in their dwelling-rooms, and making up their cartridges or fuses (straws) at night.

After giving some illustrations of the disastrous results of carelessness in the handling of gunpowder, Prof. Abel said that it naturally follows that other explosive agents, such as dynamite and gun-cotton, should be treated with similar and perhaps even greater recklessness. The apparently less dangerous nature of

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such materials when unconfined tends to render the miner even more regardless of precautions, and hence it is unquestionably wrong to foster the notion of the safety of these materials in the hands of the miner, especially as it frequently occurs that the men who use these materials are unable to read the printed instructions which are supplied by the manufacturers with the cartridges for the purpose of guarding against accident.

It does not admit of dispute that the recklessness of the miner has actually been fostered hitherto by the utter disregard of all ordinary precautions which they must but too frequently witness at the stores where the powder is sold or issued to them. The practices of small dealers in gunpowder present illustrations of ignorance and recklessness, if anything, even more appalling than those which the habits of the miners furnish. The manner in which powder is often dealt with by those in charge of the stores or magazines in quarries or mines, and who have to issue supplies to the men, is illustrated by one or two examples from a report to the Home Office by Major Majendie. As an extreme instance of recklessness the case of a man is quoted who was in the habit of boring into the barrels with a red-hot poker; on one occasion, the lid of the barrel being thinner than usual, the heated iron was thrust into the contents of the barrel, and the man fell a victim to his very original mode of dealing with packages of gunpowder.

In some mining districts it has been customary to pay no regard whatever to the suitability, in point of safety, of the localities selected for the storage of powder. It has not unfrequently been kept in large quantities (*e.g.* 500 lb.) in ordinary buildings, quite close to dwelling-houses. Even where magazines have been provided, in connection with extensive mines and quarries, many instances are on record of gross ignorance or carelessness in regard to the precautions essential to the safe handling of gunpowder.

The strenuous exertions of the Government inspectors during the last few years have already resulted in a considerable amelioration of this lamentable condition of things, although the existing state of the law affords them little power to enforce simple regulations which are vital to the safety of the people employed, and often of the neighbourhood, but scant regard being but too frequently paid to the position of even extensive stores or magazines with reference to contiguous habitations.

The utter inadequacy of the existing regulations as to the transport of powder, &c., by land or water, and the flagrant manner in which even these defective regulations are but too frequently disregarded, are matters to which public attention has been much directed since the explosion in October last, and which are but in harmony with the negligence and ignorance displayed to so alarming an extent in connection with the handling and storage of gunpowder. Thus, the packages (barrels, &c.) in which powder is transmitted to distant places are often so imperfectly constructed that the grains escape into the cart, or the hold of a vessel, where they may become mixed up with grit and be eventually trampled upon. As regards the vehicles in which the powder is transported, some regulations exist with respect to the employment of covered or uncovered carts with reference to quantities of powder exceeding considerable limits, but there is no law requiring carts or barges to be specially constructed or employed so as to exclude sources of danger. In the mining districts and even in towns powder is constantly conveyed in dangerous quantities in ordinary carts, which may have been used for carrying stones, coal, or road rubbish, and is often packed with other goods, such even as lucifer matches and petroleum; there is no regulation to prevent the person in charge from smoking while in his cart, or stopping at a public-house, leaving the powder standing at the door. Prof. Abel quoted instances of the reckless carriage of powder in public conveyances, and of the transport of very large quantities (many tons) of powder through crowded thoroughfares in large towns (Edinburgh and London) with little or no precautions. The disregard of necessary precautions in the transport of merchants' powder by *water* was dwelt upon and contrasted with the precautions adopted by Government as absolutely necessary, and some severe comments were made upon the practice, which had been common, of stowing gunpowder in barges as part of miscellaneous cargoes which include even such materials as petroleum spirit.

After referring in detail to the precautions insisted on in the transport and storage of Government gunpowder, and to the effect of recent legislation with regard to explosive substances, Prof. Abel concluded by stating that the beneficial results attainable by a systematic and thoroughly authoritative supervision, by Government inspectors, of factories and stores of explosive agents, if conducted with intelligence and discretion, have been most convincingly demonstrated by the great good which it is admitted on all sides that the inspectors have already succeeded in accomplishing, even with the very insufficient powers which the present state of law affords them. The favourite argument of some, that Government inspection must operate mischievously, by diminishing private responsibility, has certainly received no support from the results of inspection, so far as the experiment has been tried. It will scarcely be asserted that a manufacturer or store-holder who may have willingly adopted, as suggestions which the inspector has no power to enforce, measures conducive to the safety of life and property, would be careless in the application of those measures because their adoption was no longer optional, or because the responsibility for their due observance was to some extent shared by the inspector. This very system of inspection cannot fail to benefit those interested in different branches of the industry of explosives by reducing the necessity for hard and fast rules with respect to the arrangement and conduct of works, which might in many instances entail hardship or inconvenience without any real necessity, and by strengthening the hands of factory-owners, and thus rendering comparatively easy the proper observance and enforcement of regulations for the safety of the men and the works. It is, however, especially in connection with the storage, transport, and employment of gunpowder and other explosives in mining districts that efficient inspection, supported by the reasonable power which a well-considered Act of Parliament cannot fail to afford, may be confidently expected to produce important beneficial results, not the least of which will probably be the wholesome influence exercised indirectly, by the force of example, upon the miner or pitman, whose ignorance has fostered the indifference with which long habit has led him to regard the possibility of danger.

But although improved legislation, and the beneficial regulations thus supplied, may be confidently hoped to effect an important reduction in the number and magnitude of the disasters now recorded as accidental explosions, it would obviously be worse than shortsighted to encourage a reliance upon legislation alone as a safeguard against the evils which lead to casualties of this kind. Punishments inflicted for transgression of the law may engender caution, but the disasters which arise from ignorance are not likely to be importantly reduced in number by legislative enactments alone.

It is to the general promotion of education among the people, and to the spread of scientific and technical knowledge, if even of the most elementary kind, among employers and employed, that we must look for a substantial diminution of these casualties, which the uneducated mind is but too prone to attribute to accident, and the prevention of which rests, at any rate to a large extent, with those who are at present tacitly content to regard them as inevitable.

SOCIETIES AND ACADEMIES

LONDON

Royal Society, April 8.—"On the Development of the Teeth of Fishes" (Elasmobranchii and Teleostei), by Charles S. Tomes, M.A.; communicated by John Tomes, F.R.S.

Observations upon many mammals, reptiles, and fishes, led the author to the following general conclusions as to the development of teeth:—

(i.) All tooth-germs whatever consist, in the first instance, of two parts, and two alone—the dentine papilla and the enamel-organ.

(ii.) The existence of an enamel-organ is wholly independent of the presence or absence of enamel upon the teeth; examples of this have been recorded by Professor Tomes and by the author among mammalia, and are common amongst reptiles and fishes.

(iii.) Nothing justifies the arbitrary division into "Papillary," "Follicular," and "Eruptive" stages; nor does any open primitive dental groove or fissure exist in any creature examined.

(iv.) In all cases an active ingrowth of a process from the oral epithelium, dipping inwards into solid tissue, is the first thing distinguishable, although the formation of a dentine papilla opposite to its deepest extremity, goes on *pari passu* with it from the development into an enamel-organ.

(v.) A special capsule or follicle to the tooth-germ may or may not be present; when present it is in part a secondary develop-

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